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A Mobile Application for Self-Monitoring for Patients with Heart Failure

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Abstract. Patients suffering from heart failure disease have to regularly measure and document health data such as weight and blood pressure. Currently, the data gets lost or is not recorded on a regular basis due to missing reminders and lack of motivation in patients. To address these problems, we introduce a concept for an electronic heart diary (EHD), a mobile application that supports in data collection and motivates the patient. The requirements towards a digital heart diary were collected in discussions with stakeholders in a collaborating hospital. The EHD, allows patients to record their measurement data or even transfer it from a health device to the app. The data is stored in a database that can be accessed with permission of a patient by health professionals through a web application for monitoring purposes. In this way, a worsening of the disease can be detected in an early stage and actions can be taken. This can increase patient safety and prevent rehospitalisation. For motivation and supporting a long-term use of the app, we included methods for gamification and nudging into the application.

Keywords. Self-monitoring, gamification, heart failure, cardiology

1. Introduction

Heart failure is a major and growing medical and economic problem worldwide as 1–2% of the healthcare budget is spent for the treatment [1,2]. The prevalence of heart failure has increased over the past decades and a further raise is expected due to the higher proportion of elderly in the western societies. The number of hospitalisations due to cardiovascular diseases increased in the last 10 years [1]. Besides the economic burden, heart failure disease significantly impacts the life of patients. According to the Swiss Heart Foundation, one of the most important interventions in this context is to prevent the disease from getting worse [3]. Although heart failure is a non-curable disease, lifestyle changes can increase quality of life and life expectancy of patients. Additionally, a continuous and careful monitoring of daily vital signs such as weight, or blood pressure allows to recognize changes or complications at an early stage, which in turn helps to take countermeasures [4]. For this purpose, patients have to carefully monitor their weight, blood pressure and symptoms, which is currently realized by a paper-based diary. Unfortunately, patients are usually not good at self-monitoring even with the support of healthcare providers [4,5]. They often forget to record their measurements in the diary or to bring the diary to the consultation with the specialist. This complicates check-ups and makes it more difficult to identify a worsening of the

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disease. In this work, we address the question of how to improve patient's self-monitoring with the help of a mobile application. The main contribution is a concept for such applications. Beyond, we address the question how patients can be supported and encouraged in regularly measuring and recording relevant health parameters by means of the electronical heart diary (EHD).

2. Methods

This work is embedded in the "Hospital of the Future Live" project (SdZL) that targets developing IT solutions for future eHealth optimized health care processes [6]. For concept generation, we collected requirements by asking a cardiology specialist and a heart failure consultant from the hospital in Biel and Lucerne cantonal hospital for a description of the current situation and ideas on possible improvements. Furthermore, we contacted the Swiss Heart Foundation by e-mail to receive documents about heart failure, such as a heart diary and various information brochures. In order to gain a basic knowledge on self-monitoring and heart failure, we conducted a literature and web search mainly on PubMed and Google Scholar using the keywords "heart failure", "monitoring", "cardiology application", "gamification". The collected information was used to define a user story and use case scenarios. Finally, we developed our concept and implemented it in an iterative process as a native mobile application. Feedback of the specialists was continuously retrieved to improve the prototype. As a result of a literature search on the topics gamification and motivation of elderly people through healthcare applications, we decided for eNudging and gamification features to be integrated in EHD. This approach was evaluated in November 2018 by 30 persons at the prevention fair Expo 50+ in Zurich. The participants answered open and closed questions.

3. Results

The requirement analysis showed that the application should 1) support the patient in regularly recording specific health data and storing the values in a digital form in a database, 2) make the data available to the patients and the health professionals at any time, and 3) digitize the existing paper-based documents.

3.1. Electronic heart diary application (EHD)

EHD provides the following functionalities: 1) Collecting data on well-being, 2) entering measured values (weight, blood pressure and pulse), 3) reporting symptoms, 4) sharing health data with family members or health professionals, 5) providing collected data for clinical studies, and 6) providing contact details of health providers as entered by the user. The daily weight is an important value for the early detection of water accumulation in the body. Furthermore, measuring the blood pressure regularly is mainly relevant for patients where arterial hypertension causes the heart failure [7] and collecting the data improves the patients' adherence to the therapy [8]. In EHD, the user can record the weight, the systolic, diastolic value and pulse as measured by the corresponding devices (figure 1) either manually or via Bluetooth. To avoid mistakes in data collection, the app indicates what the user has to consider while measuring (e.g. that the weight should be measured in the morning after urination). Heart failure has a strong

effect on the physical and psycho-emotional quality of life [9]. However, within the treatment process, the well-being and quality of life of the patients remains often unconsidered, although this is regarded as an important predictor of mortality and re-hospitalization. The EHD app therefore asks every day for a judgement of the personal well-being on a scale of three (very good, well, not good). Further, the user is asked within the app for symptoms that can be selected from a list (e.g. pain, shortage of breath, loss of appetite). The application shows a summary of the measurement values of the current day and also provides statistics over a period of time.

Fig. 1: Concept for the electronic heart diary

3.2. Concept for patient motivation

Most patients with heart failure are elderly people, constituting up to 80% of patients suffering from this disease with both incidence and prevalence of the condition increasing with age [10]. For this reason, we considered the question, how especially the elderly can be motivated to use our app. The social aspect is one of the most important factors that can have an impact on the elderly's level of motivation [11]. For this reason, our motivation concept involves relatives or friends who can create challenges through the app upon request of the user consisting of a goal and a reward (e.g. having a joint dinner). A challenge is for example to gain 20 points within a time period of two weeks. Points can be earned by entering values for weight or blood pressure. If the user forgets to record a measurement, he loses one point. The self-determination theory proposes three dimensions of human motivation: autonomy, competence and relatedness. When these three aspects are satisfied, a higher motivation level is reached, which in turns leads to technology adoption [11,12]. Our concept to motivate patients includes these three dimensions. Autonomy is fulfilled by allowing the user to decide whether he wants to involve a relative. The user strengthens his organizational competence by regularly entering the health data and accomplishing a given task. In this way, the user feels related to his loved ones which covers the dimension of relatedness. At the prevention fair Expo 50+, 30 participants took part in the evaluation. 23 persons were over 50 years and 7 persons under 50 years. 16 out of 23 persons (70%) older than 50 would use an app implementing our gamification concept. All persons under 50 consider including relatives and friends useful.

4. Discussion

Existing mobile applications for heart failure patients are mainly designed to support patient education. The app "Life with heart failure" provided by the Swiss Heart Foundation integrates a heart diary in addition to information on the disease [13]. In contrast, our approach integrates education, data collection and continuous monitoring. For the monitoring purposes, healthcare professionals require an application that supports in accessing the patient recorded values. Such application should be integrated

with the clinical information system to facilitate the interaction. We deliberately refrained from showing interpretations of the values within the applications. This will remain to be the responsibility of the physician. The application offers features for telemonitoring. Mobile telemonitoring is effective in reducing the risk of all-cause mortality and heart failure-related hospitalizations [14].

To the best of our knowledge, no other existing application offers an integrated motivation concept as we suggest. The evaluation at the Expo 50+ already showed that elderly people feel engaged by the challenge-feature of our app. In order to achieve higher acceptance, a larger scale study with heart failure patients has to be carried out to assess the usability of the application and to judge the success of the motivation approach. So far, a prototype of the application has been developed. A direct data transfer from digital scales or blood pressure measurement devices via Bluetooth still has to be developed. Here the Continua Design Guidelines can be used because they cover the entire technological range from a sensor to a document-based dossier [15].

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